Science and Evil

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Chapter Summary

This essay will consider first how scientific developments have *enhanced the human capacity for evil*. I will concentrate on instances where advances in science directly led to enhanced possibilities for weaponry. My key examples will be chemical warfare in World War I and atomic bombs in World War II. The second part of the essay will reflect on instances where scientific advances *aid human understanding of harms*. Here I will mention the discovery of anthropogenic climate change, and then discuss in more detail the way Darwinian thinking heightens our understanding of the theological challenges of both moral and natural evil. My conclusion is that the impact of the sciences is very diverse and ambiguous, highly dependent on context, but that its disclosures about the

character of the natural world are of great value both practically and in my own discipline of philosophical theology.

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Introduction

In this essay I shall seek to subvert two obvious caricatures. The first is that the role of modern science has been almost uniformly positive, enormously enhancing our knowledge and understanding as well as making possible all sorts of beneficial technologies, and that in the few exceptions to this rule, the scientific community has itself been innocent. The second is that the main effect of science on the modern world has been to potentiate human capacity to inflict harm, both on other humans and on the biosphere. To that end I propose to consider two cases in which new science has been directly applied to give rise to technologies for inflicting types and extents of harms previously impossible. These will be the use of chemical warfare and of nuclear weapons. I then consider two cases in which science has revealed aspects of the world that were not previously suspected, and which clarify how and why harms occur – the discovery of climate change in the 20th Century and of evolution by natural selection in the 19th.

My own background is in the natural sciences, especially chemistry and biochemistry, and more recently in theology, with a particular focus on the problem of evil. This very much informs the examples I have chosen to illustrate my case, but I nevertheless consider them both representative and informative.

As I write this chapter, the Assad regime in Syria is rumoured to be considering the use of chemical weapons on its own population, and the Doha talks on climate change are approaching a point of crisis as to whether the most developed, and 'polluting' countries need to compensate the poor countries on whom much of the impact of climate change is predicted to fall. The role of the United States is interesting in both these instances. The apprehension of the Obama administration at the prospect of a compensatory framework in respect of climate change reflects not just the desire to avoid legally-binding commitments (the 'compensation' was eventually agreed in the form of 'aid'), but also the deep suspicion that persists in the Republican Congress as to whether the scientific consensus is correct on this issue. The warnings the US Government has issued to Syria indicate its conviction that the use of the science of chemical warfare would constitute a barbarous and unacceptable escalation of the civil war in that country. At once we can see how diversely science can be appropriated – its products can arouse horror, and the threat of their use can lead to immediate counter-measures. Its disclosures can summon world conferences, where nevertheless major players reject or partially reject its conclusions.

Evil

I take ‘evil’ for the purposes of this essay to include not only harms, and the resultant suffering, caused to sentient creatures by the free choices of rational agents (so-called ‘moral evil’) but also harms, and the resultant suffering, caused to sentient creatures by other factors such as predation, parasitism, and evolutionary competition, as well as earthquakes, volcanoes, droughts etc. (so-called ‘natural evil’).

I want to note a scale of values that seems to be implicit in our attitude to the infliction of moral evil. Typically, we seem to be more concerned at the infliction of harms and suffering where there is a power differential between inflictor and victim. We are especially outraged (and rightly so) by child abuse and rape. We take a gang attack on an individual to be more serious than an individual assault. We are more disturbed by the attack of a soldier on a non-combatant than by the clash of two soldiers. We also tend to regard calculated, premeditated actions to be more serious than spontaneous ones. Jesus, defending his torturers to his Father, did so on the grounds that they knew not what they did – they were incapable of making the sort of calculation that would make them fully culpable. The suffering-causing actions of governments, which are both powerful and, typically, premeditating agents, against individuals and groups, particularly disturb us. One of the great images of the 20th

Century is the Chinese protester who stands before the tank in Tiananmen Square – individual against regime, vulnerability against armoured might. There is more concern over the US drone attacks in Pakistan than over the use of special forces to achieve the same ends, presumably because vulnerability attaches to the latter, and alters our sense of power differential. But certain uses of science and technology have occasioned especial revulsion and led to strenuous efforts at prohibition, and the two cases I have chosen – chemical warfare and nuclear weapons – fall into that category. Something, then, about certain kinds of science, has a very particular relation to our attitudes to evil.

I believe we should be wary of the scale of values I have just outlined. Its great problem is that it seems to license as acceptable certain forms of harm. The battle between the Sharks and the Jets in 'West Side Story' (and that in Verona that was its source) is a roughly equal contest, not involving governments, or high-tech weaponry used from a distance. But that great story of love illustrates profoundly the depth of suffering that socially-licensed feuds can engender. Likewise, just war theory allows proportionate force, used as a last resort by a legitimate authority, but no Christian should be easy with its use in the name of the Prince of Peace. The present tragic civil war in Syria illustrates perfectly the dubiousness of scales of evil. The Assad regime has pursued its ends with increasing brutality against its opponents, including the use against civilians of armour, artillery and air-strikes. Yet there has been a sense that with the recent threat of the use of chemical weapons a line has been crossed, and the likelihood of NATO intervention has suddenly become much greater. It is not at all clear why. Terrible harms, reflecting high levels of premeditation and differentials of power, can be and have been perpetrated without recourse to the chemical agents that are now causing such concern.

There is no scope here to enter the very intricate debate about the relation between science and technology, beyond acknowledging that this relationship is itself complex, and that science sometimes leads technological development, but may also follow it. For introductions to the interplay between science, technology and ethics see Stewart, 2011; Herzfeld, 2009; Brock, 2010. In the examples I have chosen to illustrate, new science was translated more or less immediately into new ways of causing harms, the technology emerging directly from scientific advances. That is not to say that this translation is necessarily a straightforward one. In the case of chemical warfare, the early use of lachrymators proved ineffective, and the most effective agents proved to be very different from the bulk use of chlorine with which chemical warfare began in earnest. In the case of nuclear fission, the design of a bomb proved to involve a series of technical challenges that occupied a scientific team of extraordinary talent for over three years.

Science as inflictor of harms

My first example – eerily echoed by the crisis in Syria – is the development during World War I of chemical agents as ways of clearing battlefields and breaking the deadlock of trench warfare. The development of such agents is one reason what this has been known as 'the chemists' war'. The background to this development is the enormous expansion of the chemical industries of the great powers, especially Germany, from the mid-19th Century onwards. The benefits to civilization, in terms of fuels, fertilisers, dyes, and medications (to name just a few areas) were enormous. That same industry was also well geared to the production of toxic substances for the battlefield. Fascinatingly, there were efforts to prohibit such weapons even before they were introduced. The Hague Peace Conferences of 1899 and 1907 were concerned about the weapons made possible by new technologies. Hague I banned 'all projectiles the sole object of which is the diffusion of asphyxiating or deleterious gases' (quoted in Haber 1986:16). Hague II was concerned to ban 'projectiles, weapons and materials which might cause unnecessary suffering' (Haber 1986:17). As I indicated above, this licenses in a very dubious way the concept of necessary suffering. But 'poison or poisoned weapons' were specifically banned.

Nevertheless, the French possessed as early as August 1914 cartridges containing lachrymators (Haber 1986:23-24), though when used in March 1915 these were less effective than had been envisaged, as were early German attempts using lachrymators. Bulk releases of chlorine in April-May 1915 proved tactically limited (Haber 1986:36), as did the use of the much more toxic phosgene. But a new dimension was added to chemical warfare in 1917 by the use of highly toxic vesicants such as bis(2-chloroethyl)sulphide (mustard gas), the ‘king of battle gases’ (Hessel, Martin and Hessel 1940:89). Though this was not a new chemical, any more than chlorine, a new and simpler synthesis made it a potent agent of war.[1] From there on research developed apace. The arsenical vesicant ‘Lewisite’ was first prepared in 1918 and began to be manufactured after the war had ended.[2] The extremely potent nerve agents tabun (the ethyl

[1] It may also be that a report of an accident to a British chemist working with mustard gas alerted the German Chemical Society to its possibilities (Duchovic and Vilensky, 2007).

[2] The counter-agent ‘British anti-Lewisite’ was prepared by Sir Rudolph Peters’ group at Oxford during World War II. I had the privilege, while in the biochemistry department at Cambridge in the 1970s, of hearing lectures by Peters on chemical agents of warfare. Then eighty-five, he was wonderfully lucid and entertaining, and still active in the laboratory (a possibility sadly often denied now to senior scientists in retirement).

ester of dimethylphosphoroamidocyanidic acid) and sarin (the isopropyl ester of methylfluophosphonic acid) were first produced as by-products of pesticide research in Germany (for an account of the development of these choline esterase inhibitors see Tucker 2006:24-54). Never used by the Nazis, sarin was a component on the chemical attack on the Kurdish city of Halabja by Saddam Hussein's Iraq in 1988. Such organophosphorus agents can kill in tiny doses and can contaminate ground for long periods. They are the only true 'weapons of mass destruction' among known chemical weapons (Spiers 1994:3-4).

What comes across in the literature is the appetite, in time of war, to press science into immediate service (sometimes at the expense of systematic exploration of what would and wouldn't work). In World War I this attempt to exploit the possibilities of science reached unprecedented levels. But I question whether the use of the science fundamentally altered the character of the harms that were being attempted against others. Trenches and battlefields were to be cleared by whatever means necessary. Nor, despite the horrible character of the injuries caused by chemicals (so vividly captured in Wilfred Owen's poem 'Dulce et Decorum Est') is it clear that this use of technology differed so

He died in 1982.

profoundly in character from other strategies of destruction as to merit its extraordinary reputation for ignominy. This question has been well pressed by Richard Price in his *The Chemical Weapons Taboo* (1997). He notes that *The Times* newspaper of April 29 1915, responding to the first use of chlorine at Ypres argued that 'the use of "a few shells which spread death in the air" was no more inhumane than the employment of "hundreds of guns and howitzers… in order to destroy and break to atoms everything living" (Price 1997:51). Fritz Haber, the Nobel Prizewinning chemist who directed the early German use of chemical warfare, considered that 'chemical warfare was more humane than blast or flame and would serve to shorten wars and save lives.' (Tucker 2006:23) Indeed, the will to enforce prohibition of chemical warfare lagged a long way behind work on its development. In his survey of the subject L.F. Haber, Fritz Haber's son, describes the 1925 Geneva Protocol, which prohibited the use of chemical weapons, as possibly having 'moral influence' but being 'without teeth' (Haber 1986:296). The great powers continued to hold and develop chemical weapons. Richard McCarthy notes that '[b]y the middle of 1942, the United States had 1,250 tons of mustard gas on hand', (McCarthy 1970:41) though by the end of that year it had been decided that 'only the President could order a retaliatory gas attack' (42). He goes on to record a tragic incident in which over six hundred gas casualties resulted from German bombing of a U.S. ship in harbor at Bari, Italy, which carried one hundred tons of mustard gas bombs. The secrecy surrounding chemical weapons was such that the casualties did not receive proper treatment. (42-3).

I am inclined to agree with Price's analysis that the prohibition of chemical weapons in the Hague Conventions resulted from a desire to establish norms for the 'civilised' use of war as an instrument of policy, combined with a concern about the use of poisons. The latter concern is, as Price shows, centuries old (and again reflects a concern about the destabilizing of hierarchies, and the endangering of the strong). As we have seen, prohibitions on chemical agents were only effective in a very limited way in World War I.

There remains the question as to why, if chemical weapons were not considered the unthinkable barbarity that they are now painted to be, they were not used in World War II. Again, the reasons were probably complex. Price shows that the Germans had (at least) two remarkable opportunities to use such weapons – against the retreating British Expeditionary Force at Dunkirk, and against the invading Allies on the Normandy beaches. In the first case, Hitler may have wanted not to jeopardise the chances of a good peace with the British; in the second, he may have been properly apprehensive of the possible Allied response. Indeed, Price quotes a memo of Churchill's, dated July 6, 1944, in which he writes: 'I want a cold-blooded calculation made as to how it would pay us to use poison gas, by which I mean principally mustard… We could drench the cities of the Ruhr and many other cities in Germany in such a way that most of the population would be requiring constant medical attention' (quoted in Price 1997:123).

Not until 1993 was the Chemical Weapons Convention, banning not only use but production of chemical weapons, opened for signature by the UN.[3] It seems to me that the singling out of these weapons for proscription in the 1990s has much in common with the effort to ban them in the 1890s. They do not form a convenient part of the power-games by which the 'civilised' nations interact. There is a risk that they may be used to subvert such power-games. In particular, chemical arsenals may be used as deterrence, for instance, by non-nuclear nations to try and substitute for the deterrent effect of a nuclear arsenal (hence the reluctance of a group of Arab states to sign the Chemical Weapons Convention – see Price 1997:160). In observing the complexity of this issue I am not for a moment supposing that a ban on chemical weapons is not desirable, and indeed – if enforced – will not come as a great relief to the people of Syria. I merely wish to emphasise that the singling out of

[3] Interestingly, the convention banning the 'hostile use of environmental modification techniques' (such as the herbicidal warfare practiced by the US in Vietnam) preceded the chemical weapons convention by 16 years. See Zierler 2011 on herbicidal warfare. It may well be that the CWC was precipitated by Halabja, just as the convention on herbicides was a reaction to Vietnam.

such weapons is a construct of international politics, rather than an absolutely clear ethical distinction based on the character of the weaponry.

There is an interesting link between my first case-study and my second. Otto Hahn, lead discoverer of nuclear fission, served as a scientific observer in Haber's chemical warfare team in World War I. He is reported to have queried the use of chlorine on the Western Front, and been reassured that no illegality was involved (Price 1997:48). The use of nuclear fission is the most famous instance of a scientific advance being turned directly into weaponry of staggering violence. The story of how a group of physicists sent a letter to Roosevelt in 1939, signed by Einstein, to make clear to the President the significance of fission research has been well rehearsed (see for example Jungk, 1958:83-86, 106-7). The explosive power available in even the first such device exceeded many-thousand-fold that available by non-nuclear means. Fission weapons, and their yet-more-destructive successor the hydrogen bomb, transformed humans into the one species that could devastate the whole biosphere within a very short time. So this is an instance of a step-change in humans' capacity for evil.

It was in December 1938 that Hahn, working with Fritz Strassmann, first unequivocally recognized that barium, which came to be understood as necessarily the product of a process of fission, was being produced when uranium was bombarded with slow neutrons. He was greatly helped to understand the significance of his results by his recently-exiled Jewish colleague Lise Meitner and her nephew Otto Frisch.[4] Hahn himself completely rejects the suggestion of Robert Jungk that he considered concealing his results (Hahn 1970:164). And indeed, his rejection is highly plausible, given that like so many scientific discoveries, this one emerged through stumbling steps and the collaboration of a number of intellects in different teams (and not without its squabbles). The magnificent radiochemistry of Hahn and Strassmann required the insights of Meitner and Frisch to clarify the fission process, and the resulting energy release. Niels Bohr was also much involved, and – importantly - took the news to Princeton in very early 1939. The discovery that neutrons were released in the process, making a chain reaction a possibility, was made at Columbia University, not in Berlin. For a scholarly summary of the road from Hahn's laboratory to Hiroshima see Kragh 1999: 257-75. Hahn's sense that, in effect, he was simply interrogating nature, albeit a very involved and surprising aspect of that nature, is typical of the instincts of the experimentalist. When challenged on the use of his discovery Hahn is said to have replied 'I have never worked on atomic weapons and I have nothing to do with it.' (Schrader

[4] I try to explore something of the 'chemistry' of that scientific relationship in my poem 'Taboo' (2006a: 60-2).

1970:232)

Jungk notes the paradox that: ‘the German nuclear physicists, living under a sabre-rattling dictatorship, obeyed the voice of conscience and attempted to prevent the construction of atom bombs, while their professional colleagues in the democracies, who had no coercion to fear, concentrated their whole energies on the production of the new weapon’ (Jungk 1958:102). The difference was, he goes on to say, quoting an unnamed source, that (rightly or wrongly) they ‘had confidence in the decency and sense of justice of their governments’. The source went on, ‘I doubt, incidentally, whether exactly the same situation prevails in those countries today.’ I explore the question of trust between scientists and states further below.[5]

The power available from nuclear fission represents a different sort of case from chemical warfare, in that it was first employed in weaponry,

[5] A further complication of this relationship in respect of physics is that nuclear physics (as opposed to the intricate radiochemistry of Hahn and Strassmann) requires very big machines and enormous investment – as Hughes notes, in the 1930s it was already on the way to becoming ‘big science’ (Hughes 2003, 45-63) which only governments could commission.

and only then were the civilian uses in energy generation explored. The desirability of such uses remains of course a fiercely contested issue.

In terms of implementation of scientific advances with the potential for evil, three cases can be interestingly compared:

The first is the use of mustard gas, outlined above. The importance of a toxic agent that persisted in the field, and of the efficacy of the new synthesis, became evident in time of war, a war moreover which scientific establishments generally trusted their governments to prosecute with integrity. The only German hesitation about the use of mustard gas seems to have been that it might not be toxic enough (Haber 1986:117). It was finally pressed into service by a system that included within it very distinguished scientists.

Our second case is that of nuclear fission, and begins with Otto Hahn (who had been one of those same scientist-observers in our first case). He is involved in an intricate international network of chemists and physicists, and discovers something astonishing about the world of nature. He publishes it unhesitatingly and does not regret doing so despite the potential, which emerges very quickly, for the making of a weapon. He declares his science neutral. Faced with the character of the Third Reich and the Japanese Empire, the international community of scientists persuades Roosevelt that the weapon must be made.

These two cases may be compared with the decision of the molecular biology community in 1974 to hold a moratorium (voluntary, but apparently everywhere observed) on the transfer of sections of DNA from one context to another. This technique had huge potential to further biochemical research, and to revolutionise medicine (though interestingly its direct medical application has proved more elusive than expected). It also carried with it significant risks, and indeed the possibility of its being used militarily, for instance to increase the infectivity or drug resistance of pathogens. The moratorium, which lasted a year, was without parallel in science. For an account of the moratorium, and the decision to end it, see Wade 1975. [6]

To line up cases in this way immediately reveals profound differences, but it is instructive all the same. *Historical context* is clearly of the greatest importance. 'Things ill done and done to others' harm'[7] are done with much less hesitation in war than in time of peace. It is noteworthy that it was not until after Pearl Harbour that the Manhattan Project was actually launched.

The provisions on chemical warfare in the Hague Conventions of 1899 and 1907 have some analogies with the hybrid-DNA moratorium, in their

6 Wade notes that 'The conference's decisions [to end the moratorium but to replace it with tight regulation] were reached in the explicit awareness that science no longer enjoys the automatic favor of governments and society, and that if the scientists present failed to regulate themselves in an evidently disinterested manner, others would do so for them.' (Wade 1975:931). So now the issue is society's trust of science, rather than scientists' trust of their governments.

7 Eliot 1969:194.

seeking to curtail a technology before it had been developed, but significantly Hague only sought to ban use, not development, and its proscriptions were swept aside by war.

Also, *the character of the science concerned* is important. Chemistry sits in the centre of the natural sciences and is in a way their servant. It is rare that chemistry by itself reveals a deep truth about the nature of the cosmos, or of life. Hahn's experiments might seem an exception, but his results needed to be put at the service of physics for their full appropriation. A great deal of chemistry 'simply' makes substances and analyses available and understandable and useful for a whole variety of purposes. That is part of its ethos. (An example would be the discovery of the structure of the nucleotides that make up DNA, painstaking work without which the much more far-reaching structural discovery of Crick and Watson would have been impossible.) Further, chemistry is an old science, and as I noted above the mechanisms for putting its discoveries to use were very well established (particularly in Germany) by the time of the First World War.

There is perhaps more parallel, then, between the infant science of nuclear physics in the 1930s and that of molecular biology in the 1970s. These were young communities of scientists with little background in putting their discoveries to use. It is an intriguing thought-experiment to wonder whether, in a different political context, the physics community could have agreed, and imposed, a moratorium on the exploration of fission analogous to that on work with hybrid DNA. Efforts were made by Leo Szilard and others in this direction – not to suspend work, but to censor its communication to colleagues under totalitarian regimes (Jungk 1958:74-79). I am inclined to think an agreed moratorium improbable in any political context, simply because the power available as a result of the scientific discovery was so great that governments would always have been bound to take matters into their own hands. (However, efforts to restrict the use of fission technology to certain countries persist, and they remain a vital part of the current politics of the Middle East.)

Of course, many other examples could be given where science has been used to potentiate evil. There are also important cases in which well-intentioned science has led to unforeseen detriments. When I was being taught inorganic chemistry at school, two of the cases most proudly produced of the success of using the Periodic Table to benefit human life were tetra-ethyl lead as an anti-knock agent in gasoline, and chlorofluorocarbons as non-flammable, chemically stable refrigerants. Thirty years later, leaded fuel was being phased out because of damage to the brains of infants, and the first generation of CFCs were being banned because of their effects on the ozone layer. Science gave rise to the Green Revolution in agriculture, but also to the ethically highly ambiguous effects of genetically-modified crops. The use of agents such as DDT still gives hope to malaria-plagued areas, but it has long-term and far-reaching ecological effects, vividly depicted by Rachel Carson in *Silent Spring*. These agents were also made into a weapon of 'herbicidal warfare', with terrible effects on human health in Vietnam (see Zierler 2011).

War, too, has had a very ambivalent inheritance. It gave rise to the atomic bomb, but also, through the work of the cryptography unit at Bletchley Park, to the modern computer, which in turn has made possible all sorts of discoveries about the character of our universe, not to mention empowering all sorts of human lives subject to disability or isolation.[8]

Science used to disclose harms

I turn now to the first of my examples in which modern science acts an ally to human understanding in disclosing evil-causing factors in the make-up of the world. This is climate change, which has now joined major nuclear exchange as a second way in which humans could radically destabilize the biosphere and render it much less habitable. For an account of how much damage a six-degree rise in global mean surface temperature would do (let alone a 'runaway' greenhouse effect) see Mark

8 A good example of the knowledge only made possible by computers is the development of chaos theory through the computational modeling of Edward Lorenz and colleagues in the 1960s. The mathematical background had been sketched by Henri Poincare in the 1890s, but not until computers could run a large numbers of versions of a system in a short time could the beautiful world of the strange attractor be discovered.

Lynas's book *Six Degrees*. A 'six-degree' world would be one of ferocious hurricanes, oxygen-starved oceans supporting little life and subject to upwellings of highly toxic hydrogen sulphide, and huge releases of methane from the tundra leading to atmospheric explosions and damaging the ozone layer (Lynas 2008:217-41).

The possibility that atmospheric carbon dioxide could affect the balance between absorption and radiation of solar energy has been known since John Tyndall's work in 1864. However, not till 1960 was there good evidence that atmospheric carbon dioxide was increasing. That the climate is now changing is strongly supported by evidence such as global temperature records, changes in seasons and the behavior of wildlife, sea-level rise, melting glaciers, reduction in Arctic sea-ice, and shrinking of ice-sheets.[9] Without the insights of modern science we would have no way of linking these effects to human activity. However, the consensus of the Intergovernmental Panel on Climate Change (IPCC) is strongly that these changes have been precipitated by humans' raising the levels of greenhouse gases, especially carbon dioxide, in the atmosphere.[10]

One interesting development in science in the last few years is the tendency to ascribe every major extinction event (and destruction of

9 www.metoffice.gov.uk/climate-change, accessed 14 December 2012.
10 www.ipcc.ch, accessed 15 December 2012. For a summary of the science of climate change see Burroughs

human society) to past climate changes. For an example of such thinking see Finnegan *et al*. 2011; for a summary article see Biello 2007.

It was thought until very recently that none of these historic changes could have been human-induced. Only in the last two hundred years, through the burning of large quantities of fossil fuels, did it seem that humans had the capacity significantly to increase levels of atmospheric greenhouse gases. A recent study however suggests that it is at least possible that human-induced extinction of large herbivores such as the mammoth could have reduced atmospheric methane sufficiently to precipitate the last ice age (Smith, Elliott and Lyons 2010). The more general point is that, despite the rhetoric of James Lovelock's writings on Gaia (see e.g. Lovelock 1989), atmospheric conditions on Earth are not absolutely stable. Disruptions to those conditions can be occasioned by a wide variety of causes – asteroid impact and volcanism being the two most commonly invoked. These disruptions have had very profound effects.

In a sense the bitter wrangle between the scientific community and the 'climate change deniers' misses the point. It is impossible to be completely sure what combination of effects has given rise to the climate change that has recently been experienced. There may be a range of natural factors, as well as human activity (itself conducted – at least until recently - in ignorance of the damage it might cause) behind the effects that are already being experienced, such as ice-cap melting, increasing flooding and intensified hurricanes. But what both ‘sides’ ought to be able to agree is that continuing to force the climatic system by allowing the concentrations of greenhouse gases to rise further is extremely hazardous and liable to lead ultimately to the extreme effects of which Lynas writes. Fascinatingly, Lovelock’s own recipe for minimising the effects of climate change, and preventing Gaia from ‘throwing us off’ is the large-scale use of nuclear power (Lovelock 2006). For a sense that that alone will not be enough see Pacala and Socolow 2004. On the inadequacy of current policy initiatives on climate change mitigation see Latin 2012.

This discussion introduces the larger debate as to whether human response to the present crisis should be of a ‘technofix’ variety, using big science to get us out of our big mess, or whether our way forward lies more in an effort to become in Aldo Leopold’s phrase ‘a plain citizen of the biosphere’ (Leopold 1949). I explore this issue further in Southgate, 2006b. It is an issue that lies largely beyond the scope of this essay; I only note here that a technology, nuclear fission, that was first designed to do previously inconceivable harm is now proposed as a way to salvage the human race from a crisis – major climate change – that it precipitated in all innocence.

Incidentally, another example of science revealing something very unexpected (to many) about the world would be the psychological experiments of Stanley Milgram at Yale on obedience to authority. Milgram demonstrated that there was a most disconcerting willingness among intelligent human subjects to inflict harms in response to the instructions of authority figures. While the ethics of this study have been questioned, its results are telling, and to most people a very surprising disclosure of the character of human nature. Theologians of original sin will have been the least surprised.

My last case-study – the suffering of non-human creatures in evolution - may seem a curious one to choose. Chemical and nuclear warfare are moral evils made possible by science. Climate change can as we have seen be occasioned purely by non-human causes, or it may be exacerbated by human action and thus its ill-effects become a combination of moral and natural evil. The sufferings caused by predation and parasitism are pure natural evil – indeed they form as I have claimed elsewhere a special branch of natural evil that may be called 'evolutionary evil' (Southgate, 2008, ppp). This evil predates the evolution of human beings by many millions of years.[11] Such suffering is not therefore a charge against human beings (as everyone who has

11 Peter van Inwagen describes this as one of the (only) two contributions science has made to natural theology (van Inwagen 2006:112). In doing so he not only omits some other very important contributions, but also the teleological aspect to evolutionary suffering that I go on to discuss below.

grasped the science of evolution, with the seeming exception of William Dembski, has now seen). Rather, for the Abrahamic monotheist at least, it is a charge against the goodness of God the creator of the world and (in the words of the Niceno-Constantinopolitan Creed) the ‘giver of life’ through the Holy Spirit.

The first great gift that science gives us in respect of this problem is to make clear (or as clear as we can be about the experience of species other than our own) that non-human animals do experience pain and distress, which in some cases can indeed be regarded as suffering. This insight comes both from observation of animal behaviour: the way animals avoid noxious stimuli, and favour damaged limbs, for example; also the way social animals when hurt cry out for assistance, and from neurophysiological studies of brain function and hormonal activity (see deGrazia 1996:Ch. 5). All of these lines of evidence stress the commonalities between the experience of human and that of other animals. So it is no longer possible to hold as some have persisted in doing that non-human creaturely suffering is not real. We have moved a long way from the conclusion that the distinguished biologist and theologian, Charles Raven, was still able to draw in 1927 that ‘[I]t may be doubted whether there is any real pain without a frontal cortex, a foreplan in mind, and a love which can put itself in the place of another, and these are the attributes of humanity’ (Raven 1927:120)

The theological problem that the world God created contained creatures tearing each other apart was known long before the work of Darwin. Already in the 13th Century Aquinas concerned himself with how lions are to eat (though the Psalmist and the author of Job seem less concerned[12]). The famous phrase 'nature red in tooth and claw' was written by Tennyson ten years before the publication of *The Origin of Species*. But the decisive contribution of Darwin to the problem of theodicy was to show that creaturely suffering is not just incidental to evolutionary processes, but intrinsic to their functioning. In Holmes Rolston's wonderful phrase 'the cougar's fang has carved the limb of the fleet-footed deer, and vice versa' (Rolston 2006:134). Rolston has done much to help us see how some of the characteristics we most admire in animals (including ourselves) have been refined by certain sorts of evolutionary pressures and strategies for responding to them (Rolston). It is this interweaving of values and disvalues in evolution that caused Darwin to write both that 'There is grandeur in this view of life' (*Origin of Species*), and in a letter to J.D. Hooker that 'what a book a devil's chaplain might write on the clumsy, wasteful, blundering, low and horridly cruel works of nature!' [13]

[12] See e.g. Ps. 104. ; Job .

[13] www.darwinproject.ac.uk. The letter to Hooker, dated July 13 1856, is

This intrinsic coupling of suffering to natural selection, which Darwin's work strongly suggested, exacerbates the problem of evolutionary theodicy by making it seem that God has *used* suffering to further what were presumably divine selection.[14] Strictly speaking this is an insight from before the period on which this volume focuses, but confirmation that natural selection could deliver large-scale changes from small genetic variations had to await the so-called 'new synthesis' on the 1940s.

Actually there is a further aspect to this problem, of which Darwin was unaware, and which has not to my knowledge yet been discussed in the literature. This relates to the origin of heritable variation within species. Natural selection can only work on such variations, and we now know that these arise through various processes of mutation (including the recombination made possible by sexual reproduction). We also know that most of this mutation is either neutral or harmful and it may occasion great suffering, as we know from the various heritable diseases that have survived in the human. In other words *both natural selection itself, and what makes it possible, are sources of suffering, and this suffering is, as noted, intrinsic to the processes of creaturely change.*

Our scientific insights, then, allow us to dispense with crude models of

catalogued as Letter No. 1924. (accessed August 13 2007).

[14] Though this would be disputed by a thinker such as Ruth Page.

the designer God such as were propounded up to time of William Paley. In this sense Darwinism is as was claimed by Aubrey Moore in *Lux Mundi* 'the disguised friend' of faith (see Peacocke 2001). As it happens, direct divine design has recently attempted a reappearance in theology through the work of intelligent design theorists such as Michael Behe. For a range of assessments see Pennock . The theodicy problems posed by such a model of divine action, when combined with an overall model based on evolution, seem unbearable. This would be a picture of a God who created by means of the process of evolution, but stepped in to repair or improve the products of that process at various points, while refusing to act to prevent the vast rafts of creaturely suffering that that process engenders. It is more and more clear to me that intelligent design, for all its professed agnosticism about the evolution-creationism debate, only works at all theologically in a young-earth creationist model in which natural evil is the product of the sin of the first humans. Such a model is completely out of keeping with all that the natural sciences tell us about the age and character of the world.

But the problem posed by what I have called the 'teleological aspect of evolutionary theodicy' – the sense that God might have used a suffering-filled process for God's own ends – remains a severe one, only just beginning to be addressed (Southgate, 2008; 2011). Both the recent monographs on evolutionary theodicy (Southgate, 2008; Murray, 2008) call for a ‘compound’ approach, recognizing that no one argument is likely to be satisfactory by itself. Both are attracted to the argument that certain values can *only* evolve in the presence of certain disvalues (see also Attfield 2006:Chs. 6-7; Alexander 2009 on this ‘only way’ or ‘package deal’ argument). That must surely be a significant element in any theodicy that faces the teleological charge mentioned above, in respect of the suffering caused by predation and disease. Importantly, a similar argument can be mounted in respect of other aspects of natural evil, such as the earthquakes and volcanoes generated by tectonic activity. What is important for this present discussion is that scientific insights into evolution have forced theologians to think more deeply about the problem of non-human creaturely suffering in evolution. However, I have become convinced that that argument by itself will not suffice. It is an argument that seeks to justify a system, in terms of the balance of values it offers against disvalues. But suffering is experienced by individuals, and sufferers are not consoled by systems, even if they were to be aware of them. The whole tenor of theodicy since the Holocaust has been away from any sense that larger systems of meaning dissolve away the significance of the individual sufferer. For a very thoughtful exploration of the inadequacy of traditional theodicies in this regard see Surin1986. Evil, then, must be addressed at the level of the sufferer, whether that be a tortured human, a fawn trapped in a fire, or a sealion tossed and torn apart by orcas. For the Christian theologian that may mean affirming God's co-suffering with every creature that suffers (Peacocke ; McDaniel 1989; Southgate 2008. It may also mean positing eschatological fulfillment for creatures who know no flourishing in this life (Edwards 2006; Russell 2008; Southgate 2008). There were hints of this in the Christian tradition (for example in the thought of John Wesley) but in the light of the theodicy problem as science now shows it to us, this emphasis is coming to be the mainstream view.

My last case-study, then, shows how the science of creaturely harms moves us beyond the ancient answers derived by the Christian tradition from its foundational texts (especially in this case Genesis 3), and enables theology to explore a more challenging but in the end a far richer model of the relationship of God to creatures. It also, as colleagues and I have indicated elsewhere, allows a re-reading of some scriptural texts in ways that may help Christians engage with the present ecological crisis (see Horrell, Hunt and Southgate, 2010).

Conclusion

What I have tried to stress in this essay is the complex and ambiguous relationship of the modern sciences to evil. The sciences have been used in a range of ways to potentiate the infliction of moral evil – these ways, and the willingness to develop and use them, have varied in complex ways with the context, scientific, technological and political, in which the possibilities of such potentiation have appeared. But I have questioned any simplistic model for understanding the role of science, just as I have also questioned certain common assumptions about particular sorts of 'scientific' weapons, especially chemical warfare.

I have gone on to show that the sciences also reveal the character of evils in ways that may not have been obvious, or even detectable, by other aspects of human wisdom. These evils may be engendered, or exacerbated, by humans, but science also helps us see more clearly the character of natural evil.

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